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The tarsal sensory system of *Amblyomma variegatum* Fabricius (Ixodidae, Metastriata)

II. No pore sensilla

by

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With 13 figures

ABSTRACT

Five types of no pore (np) sensory hairs occur on the tarsus I of the tick *Amblyomma variegatum*. Np/A and np/B sensilla are unimodal mechanoreceptors. Np/C sensilla are bimodal containing mechanosensitive and thermosensitive units. Np/E and np/D sensilla are restricted to the anterior pit of Haller's organ and are considered as thermo- and/or hygroreceptors.

INTRODUCTION

According to the classification of arthropod sensilla proposed by ALTNER (1977), one has to distinguish between wall pore, terminal pore, and no pore sensilla. This system uses ultrastructural features (modality specific structures) for the distinction of sensory hairs.

Following the paper dealing with the wall pore and the terminal pore sensilla of the first tarsus of *Amblyomma variegatum* (HESS & VLIMANT 1982) we complete here the ultrastructural study of tarsal sensilla with the description of the no pore sensilla.

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No pore sensilla are mono- or multimodal sensory hairs reacting to temperature, humidity, or mechanical stimuli (Altner & Prillinger 1980).

As discussed previously (Hess & Vlimant 1982), the designation of tick sensilla is a matter of conjecture. We use here the conventional names introduced by previous authors, but we will also give the designation developed in our laboratory. This system uses letters for the four faces of the tarsus (d for dorsal, v for ventral, la for lateral anterior, lp for lateral posterior), a roman figure to designate a group of sensilla (numbering in disto-proximal direction), and a cipher to desingate the position of a distinct sensillum within a group (numbering in antero-posterior and disto-proximal direction) (fig. 1). Thus it is possible to indicate unequivocally the position of a sensory hair.

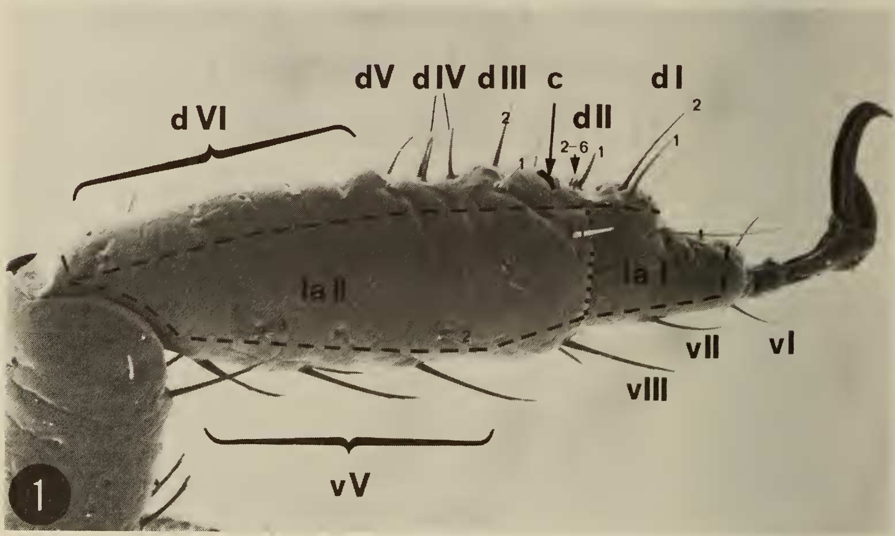
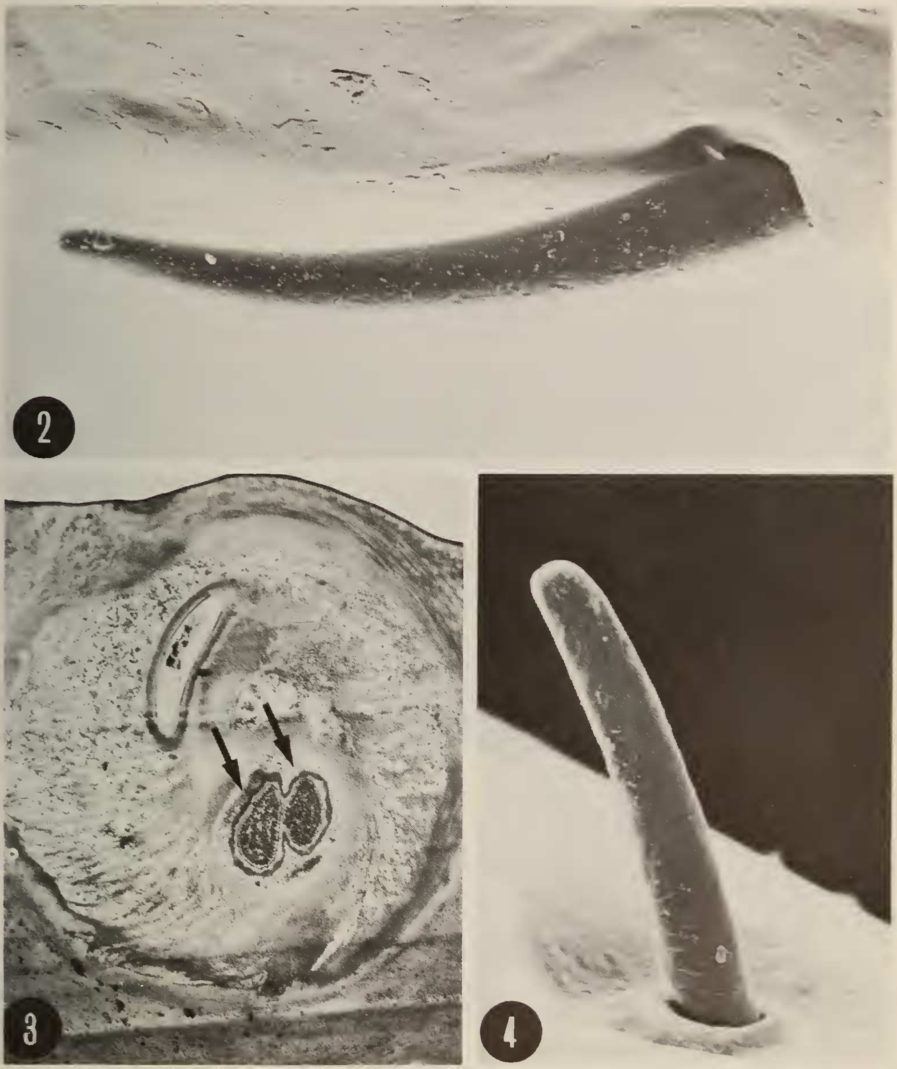


Fig. 1.

Nymphal tarsus with dorsal (d I to d VI), ventral (v I to v V), and lateral anterior (1a I, 1a II) groups of sensilla. Group v IV is lacking in larvae and nymphs. In the groups d I to d III and 1a I, 1a II, the mode of individual numbering of the hairs by ciphers is indicated. Dashed lines indicate the limits between the dorsal, lateral anterior, and ventral faces. The dotted line follows the pseudosegmental groove which is the limit between the groups 1a I and 1a II. Further information in the text. (224 ×).

MATERIAL AND METHODS

Tarsi I of larvae (L), nymphs (N), and adults (A) of *Amblyomma variegatum* were used in this study. The ticks were reared on bovines for us by Ciba-Geigy Ltd., Domaine des Barges, Vouvry, Switzerland. Fixation procedures were those described previously by Hess & Vlimant (1982). Observations were made on a Philips 201 transmission electron microscope, and on a Philips 500 scanning electron microscope at acceleration voltages of 8-12 kV. Every type of sensillum has been studied on tarsi originating from 4-8 different individuals.



FIGS. 2-4.

2: Np/A sensillum of an adult. (1230 ×); 3: Cross section through the base of an adult np/A sensillum with 2 tubular bodies (arrows) but no further innervation. (12.920 ×); 4: Np/B sensillum of an adult. (2100 ×).

RESULTS

Five different types of no pore (np) sensilla exist on the first tarsus of *A. variegatum*.

Np/A sensilla

These long (L: 70-80 μm, N: 80-100 μm, A: 90-130 μm) sensilla chaetica are situated on the ventral face of the tarsus (groups v I, v II, v IV, v V, fig. 1). The shorter ones are slightly bent towards the tarsus (fig. 2). The longer ones, which resemble morphologically the np/C sensilla (fig. 5) have 1 or 2 small lateral outgrowths and/or a bifid tip. The cross section of a np/A sensillum is elliptic. The reduced central cavity is of irregular shape. Two sensory cells with a tubular body each, innervate the socket (fig. 3).

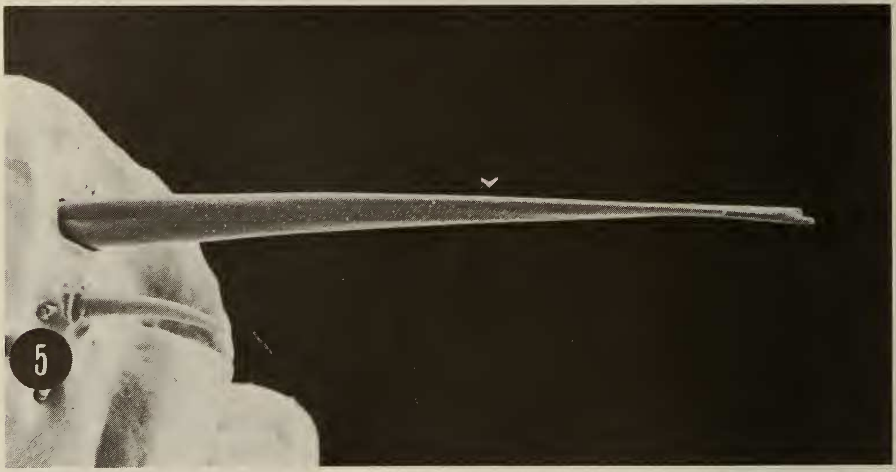


FIG. 5.

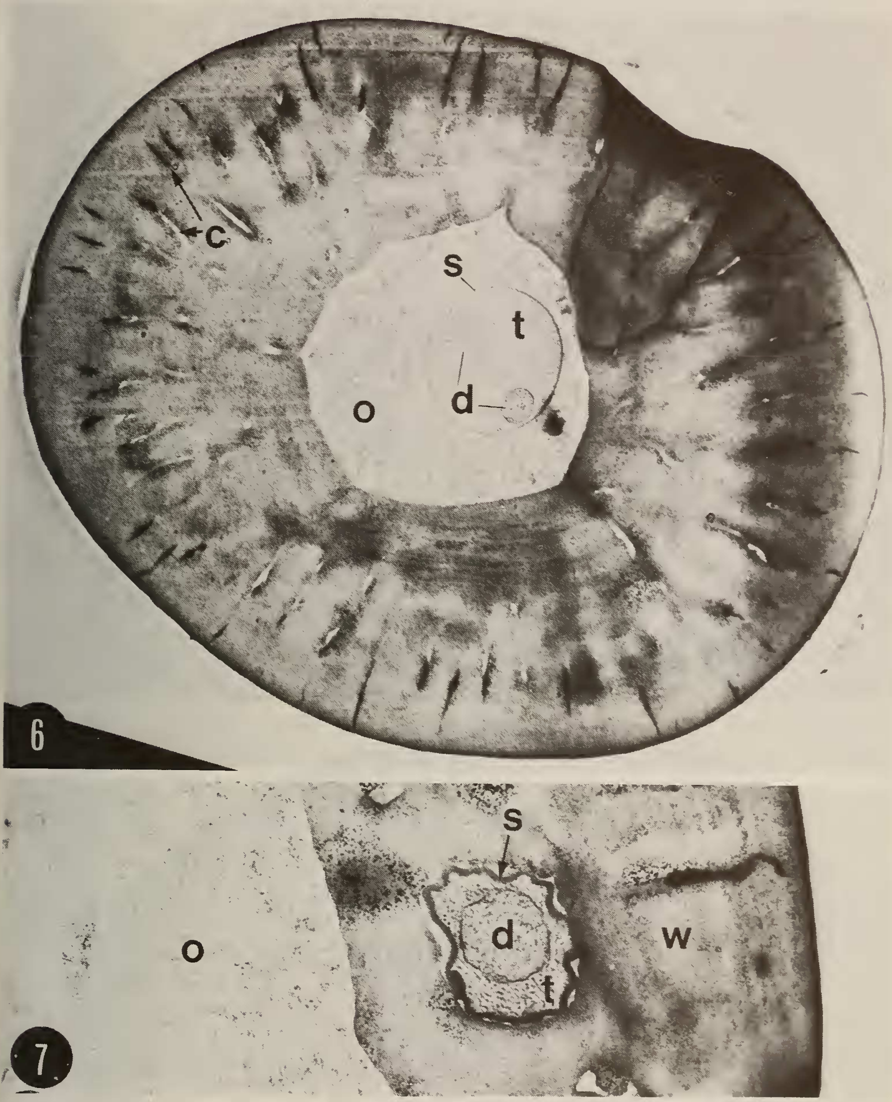
Np/C sensillum (d I 2) of an adult. (500 ×).

Np/B sensilla

These are short sensilla chaetica of the dorsal and lateral faces of the tarsi. In adults they are typically blunt-tipped (fig. 4), in nymphs and larvae they are tapered and possess several lateral outgrowths, thus resembling np/A sensilla. As in the former type, the central cavity is reduced and the socket is innervated by 2 sensory cells terminating with a tubular body each.

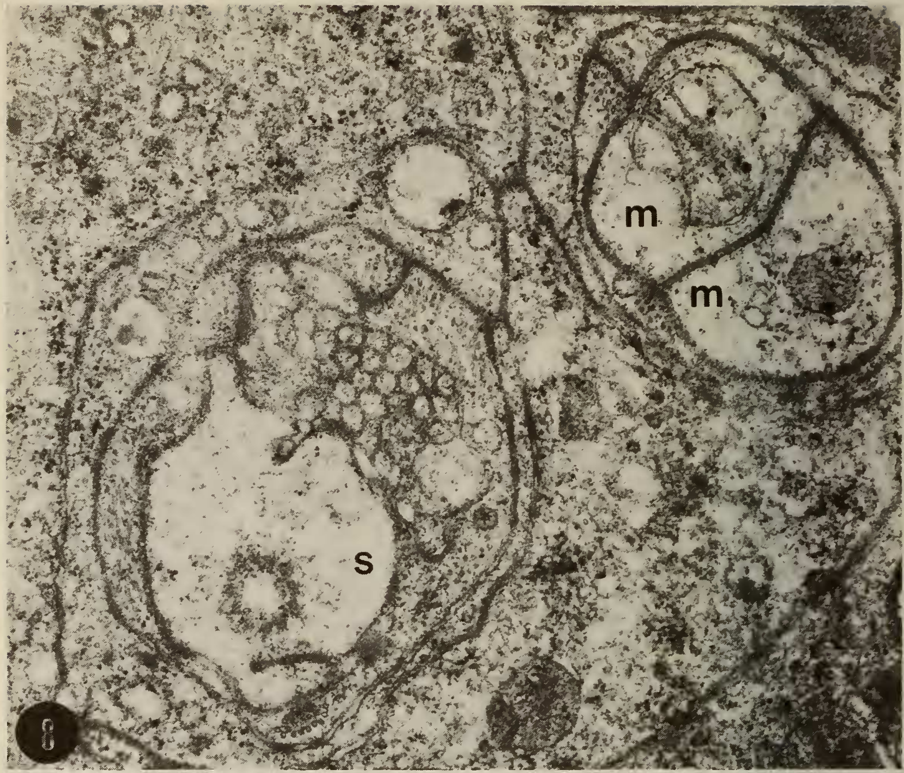
Np/C sensilla

These sensilla chaetica are particularly long in adults (L: 50-60 μm, N: 80-100 μm, A: 180-220 μm). They have a circular or slightly elliptic cross section and an apex with 2 or 3 tips (fig. 5). Two hairs of this type occur distally on nymphal and adult tarsi I.



FIGS. 6-7.

6: Cross section near the base of the np/C sensillum d I 2 of a freshly hatched adult. The inner receptor lymph cavity is still filled out by the thecogen cell (t). The 2 dendrites (d) are enclosed in a sheath (s). o: outer receptor lymph cavity. The canals in the setal wall are pore canals (c) found in the cuticle of the whole body. (10.400 ×); 7: Shaft wall of a np/C sensillum, section distal to that in Figure 6. The sheath (s) and the remaining dendrite (d) are enclosed in the wall (w). The thecogen (t) cell still occupies the inner receptor lymph cavity. o: outer receptor lymph cavity. (23.980 ×).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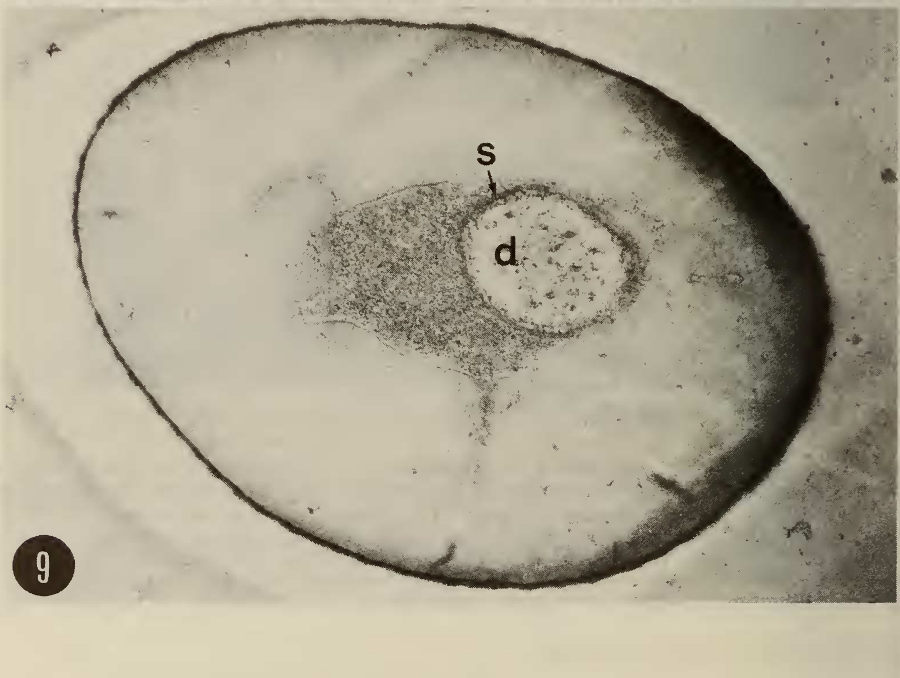
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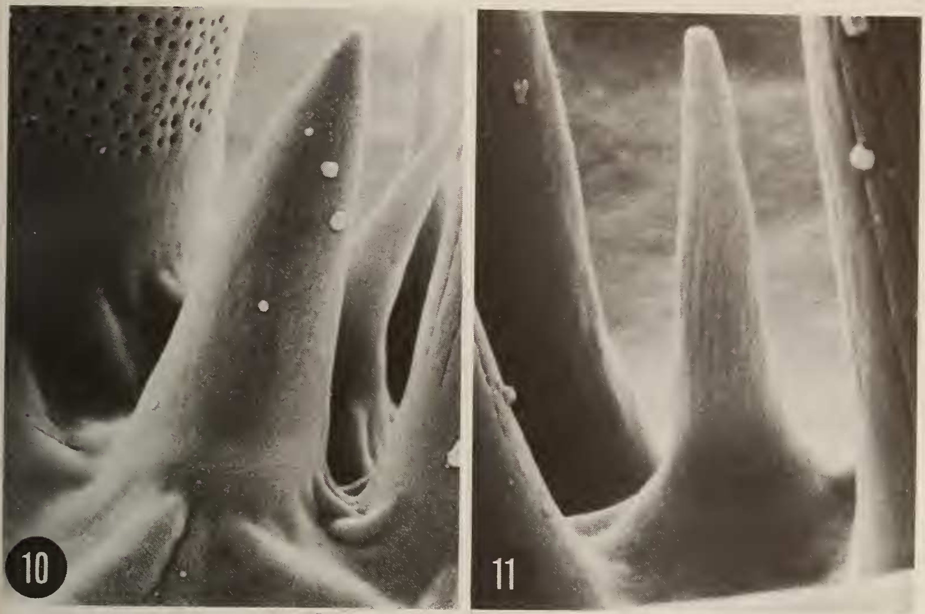
The one is situated on the dorsal face (sensillum d I 2, fig. 1), the other is situated on the latero-anterior face (sensillum la I 1, fig. 1). The lateral sensillum is deficient in larvae. The socket of these bristles is innervated by 2 sensory cells with tubular bodies. Another set of either 1 or 2 neurons innvervate the central cavity of the shaft with unbranched dendrites (fig. 6). The two np/C hairs of adults and the dorsal np/C sensillum of nymphs have 2 sensory cells. One of them is thicker and extends much higher into the shaft than the other which terminates shortly after the base. Both are enclosed in a common sheath which is attached in its distal part to the wall of the shaft. In some adults, the sheath and the longer dendrite are seen to penetrate into the setal wall (fig. 7). The situation is slightly different in the lateral nymphal and the larval np/C sensillum which possess (besides the tubular bodies) only one sensory cell innervating the shaft (fig. 8). In these sensilla, the dendrite is in close contact with the cuticle of the shaft, but it has never been seen to penetrate into it (fig. 9).



FIGS. 10-11.

10: Np/D sensillum of an adult. (5930 ×),
11: Np/E sensillum of an adult. (9880 ×).

FIGS. 8-9.

Section below the base of the larval np/C sensillum with 2 mechanosensitive sensory cells (m), and the ciliary region of the sensory cell which innervates the shaft (s). (36.950 ×); 9: Larval np/C sensillum. The single dendrite (d) is in close contact with the shaft wall. s: sheath. (32.620 ×).

Np/D sensilla

These are small sensilla basiconica (L: 8-9 µm, N: 8-10 µm, A: 8-10 µm) situated in the anterior pit of Haller's organ (sensillum d II 4) (fig. 10). The relatively thick wall is traversed by longitudinally running canals arising from the base where they communicate with the outer receptor lymph cavity. Thus the wall has a somewhat spongious appearance on cross sections (fig. 12). Each of the 3 (exceptionally 2) sensory cells possesses an unbranched dendrite. In the cases of only 2 sensory cells, one of them may have 2 outer dendritic segments. The sheath which separates the inner and outer receptor lymph cavities completely, is attached to the base of the shaft.

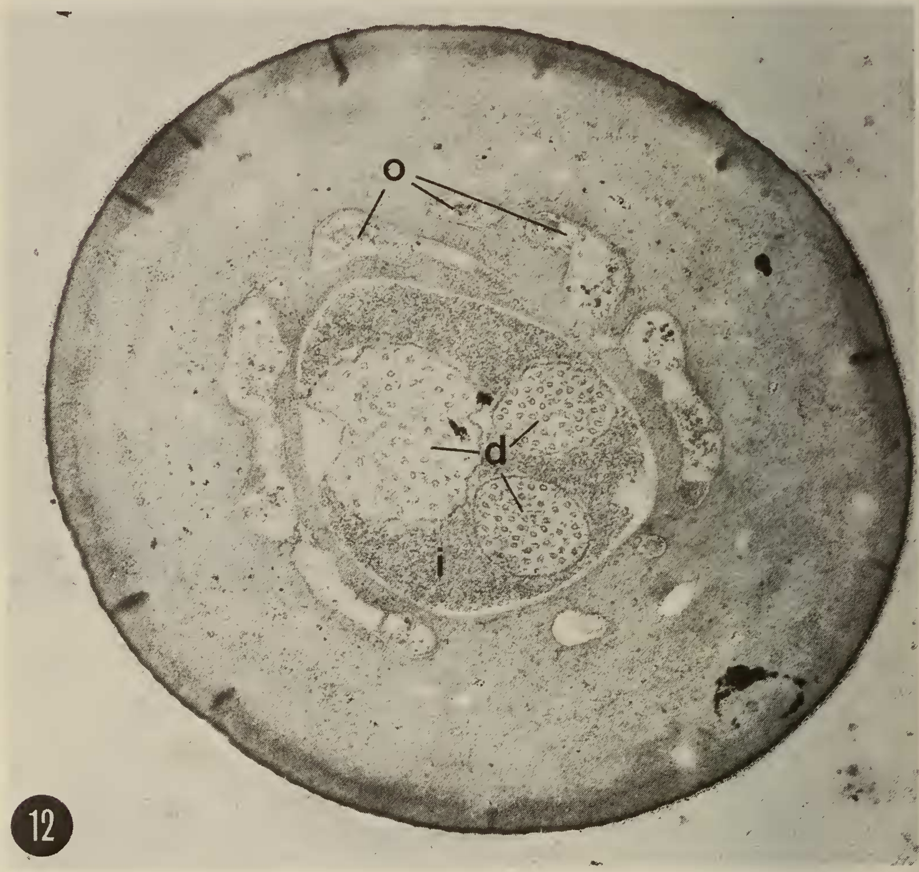


FIG. 12.

Cross section of an adult np/D sensillum near the base with 3 unbranched dendrites (d) in the inner receptor lymph cavity (i), and longitudinal canals of the outer receptor lymph cavity (o). (37.790 ×).

Np/E sensilla

These sensilla trichodea are the smallest bristles of the tarsi (L: 6-7 μm, N: 6-8 μm, A: 7-9 μm) (fig. 11). Two of them occur in the anterior pit of Haller's organ (sensilla d II 2 and 3). Their surface is conspicuously striated or grooved but there are no communications between the central cavity and the grooves (fig. 13). The wall is relatively thin. The 3 unbranched dendrites originating from 3 neurones are tightly packed in the lumen. The sheath is attached to the base of the shaft.

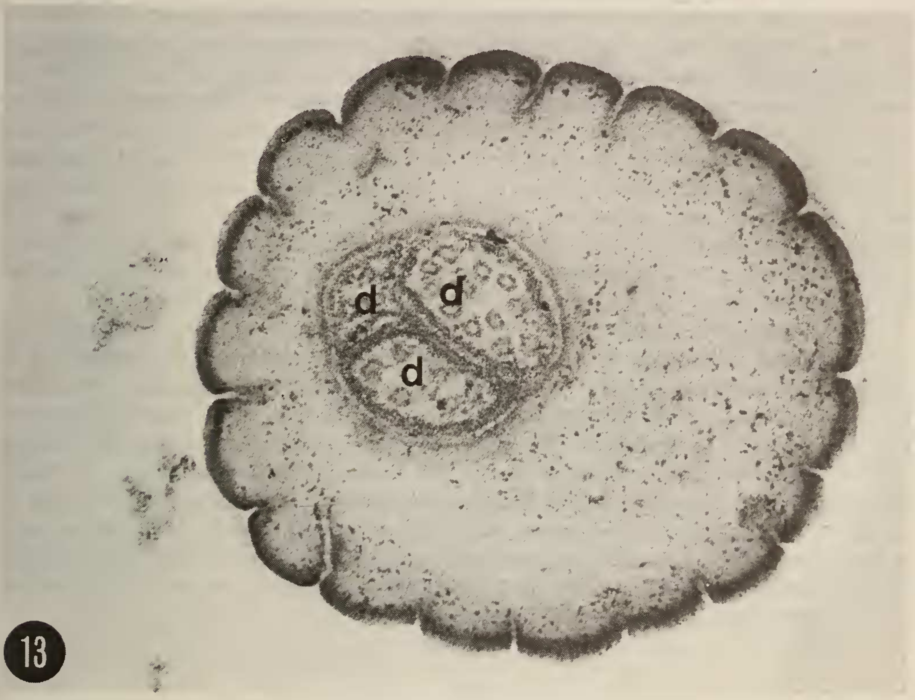


FIG. 13.

Cross section near the tip of an adult np/E sensillum with surface grooves and tightly packed unbranched dendrites (d). (109.680 ×).

DISCUSSION

Np/A and np/B sensilla have a socket which is innervated by two sensory cells with tubular bodies, but they lack further innervation. Hence they are considered as monomodal mechanoreceptors. The 2 types are distinguished, especially in adults, by their external morphology and by their position on the tarsus. The long np/A sensilla provide the entire ventral face with mechanosensibility. This sense can be employed not only for simple touching but possibly also for the detection of substrate vibrations as known from scorpions (Brownell 1977). The short lateral and dorsal np/B sensilla cover a relatively small surface with their shafts. They can be considered as organs of touch.

Np/C sensilla are of particular interst as they possess, besides the 2 mechanosensitive units, another set of neurones which innervate the shaft. The function of the latter has recently been investigated electrophysiologically in adults by Hess & Loftus (paper in preparation). The 2 cells are antagonistic thermoreceptors. The one is a warm cell reacting to temperature jumps with an increased firing reaction, the other is a cold cell which reacts to temperature drop with increased firing. As these hairs are found distally on the first tarsus, they are without doubt precious organs for host location. As the larval and the lateral nymphal np/C sensilla possess only one dendrite in the shaft, they lack either the cold or the warm cell. It will be interesting to determine which of the cells is deficient, and if there are behavioral or ecological consequences because of this fact. The dendrites of np/C hairs are in close contact with the wall of the shaft, in some adults the longer dendrite penetrates even into the cuticle. The penetration of the dendrite into the shaft wall could represent a particular adaptation to thermoreception (modality specific structure), reducing the distance between the surface and the dendrite. In larvae and nymphs this adaptation would not occur as the setal wall is still much than in adults. But why did we not observe this feature in all adult np/C hairs? It is possible that it occurs in all adult np/C hairs, but that it has not been observed because of insufficient fixation of the dendrites. The preservation of cellular structures is indeed much more difficult in no pore sensilla than in sensory hairs with pores.

Np/D and np/E sensilla have not yet been investigated electrophysiologically as they are difficult to access with microelectrodes. They are situated in the anterior pit of Haller's organ and have therefore been described in detail from *Amblyomma americanum* (Foelix & Axtell 1972), *Hyalomma asiaticum* (Leonovich 1978), *Ixodes persulcatus* (Leonovich 1977), *Ixodes ricinus* (Thonney, in preparation), *Argas tridentatus* (Leonovich 1979), *Argas arboreus* (Roshdy *et al.* 1972). Evidently from these papers, np/D and np/E sensilla of *A. variegatum* do not seem to be fundamentally different from those of the above cited species. It is however important to underline that these sensilla have no pores (pore canals are not pores!) even though Foelix & Axtell (1972) had postulated pores for these setae. As np/D and np/E sensilla have neither pores nor tubular bodies, they are considered as thermo- and/or hygroreceptors.

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